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while gladly acknowledging the great mathematical learning and originality exhibited in that and every paper by Mr. Cayley, Sir W. Rowan Hamilton thinks it right to state, that he was led to his own results, respecting the *relation* (above assigned) between *ten points on the surface of the second order*, not by any system of *co-ordinates*, but by considerations of *vectors*, and by seeking to extend to *ellipsoids* the results respecting *cones*, which he had submitted to the Academy in July, 1846, and had also published in the Philosophical Magazine for the following month, as derived from the Calculus of Quaternions.

Mr. M. Donovan handed in a paper on a new and singular acoustic phenomenon produced by tuning-forks.

Mr. David Moore, Curator of the Royal Dublin Society's Botanic Gardens, communicated the following details of the results of physiological experiments on the formation of wood in plants, made in the Royal Dublin Society's Botanic Gardens, Glasnevin, between the years 1839 and 1851:—

“ It may appear remarkable in vegetable physiology, that what has long been considered an axiom should now be gravely disputed by one of the best physiologists of the present time. Dr. Schleiden, of Jena, in his admirable work, ‘ Principles of Scientific Botany,’ flatly denies that a downward current of elaborated bark-sap either does or can take place in plants, which opinion gives to the experiments I propose to describe much additional interest. At the time my experiments were commenced, and for several years afterwards, the descent of the sap in vegetables does not appear to have been doubted, the whole theory of wood-formation resting on the fact of such being the case. It was, therefore, more with a view of eliciting information on the latter subject, than to

prove or disprove that sap circulates, as it has generally been considered to do, they were undertaken.

“Before entering into details, I shall take the liberty of very briefly stating to the Academy the views held on this important subject by Drs. Lindley and Schleiden, which are entirely antagonistic. The former author, in his ‘Theory of Horticulture,’ at p. 28, makes the following statement:—‘When sap leaves the earth and passes into the stem, it ascends by the woody matter of the finest fibres of the root; having left them, it flows into the new wood from which those fibres emanated, and passes along this until it reaches the leaves; on its return from them it descends through the liber, in part passing off horizontally through the medullary rays. Wherever it passes it deposits a portion of its solid parts,’ &c. Dr. Schleiden, on the other hand, denies that wood is formed by a descending bark-sap. In his chapter on the ‘Reproduction of Plants,’ in ‘Principles of Scientific Botany,’ p. 535, when treating on grafting, we have the following statement:—‘Yet the stock must always exert a greater or less influence on the eye or graft, as the sap brought to it must pass through the cells of the stock, and become changed there. In this case the relations are too complicated to enable us to offer an explanation. All that is known on the subject is detailed in manuals of horticulture. I will mention one case. If the branch of a quick-growing plant is grafted upon a very slow-growing one, as, for instance, the branch of a plum upon a sloe-stock, the graft will grow rapidly, but not so the stock, which retains its slow-growing character; a striking example of the permanency of the specific life of the stock, and, as it appears to me, affording a fatal argument against the pretended descent of the sap. If a descending bark-sap existed, the sloe-stock would be naturally covered with annual rings of plum wood from the graft, and it would grow in proportion to the growth of the graft, but this is by no means the case, for the new annual rings are formed, not

out of a descending bark-sap, but out of a cell-development of the cambium already existing in the stock, and having essentially the same characters. The formation of new wood of the nature of the graft has always been taken for granted, in order to prove the descent of the bark-sap; but we find that this wood does not partake of the nature of the graft, and that it must, therefore, be formed independently of any descending juices.' These being the views held by the best authorities on the matter at present, I shall now detail my experiments, and show how far they bear on either.

" My predecessor, Mr. Niven, had been conducting some physiological experiments before he left the Botanic Gardens, the results of which are already before the Public. I consider, however, it only just on my part towards him, that I shall here state my principal experiment to be founded on one he had commenced, though we do not appear to have been aiming to attain similar objects. He had cut several trees more or less through their boles in various ways, one of them a large horse-chestnut tree, then four feet in circumference, and now four feet nine inches. At three feet from the surface of the ground, two deep incisions had been made through the stem, crossing each other at right angles, and reaching the circumference on each side (Fig. 1). The tree was thus left growing on four separate pillars of wood, alburnum and bark, but no results, that I am aware of, were deducible from this experiment when I commenced the following. Seeing that it afforded an excellent example for observing the growth of woody matter, as it would form to fill up the perforations through the stem, I examined the portion of the tree where it was cut, and found that the heart wood was completely dead, and beginning to decay, at both the upper and lower lips of the cut. It, therefore, could render no assistance whatever for the phenomena of life being carried on through its medium. The ascent of the sap and formation of wood must then have depended altogether on the functions of the

alburnum and cambium, which rested on the four pillars of dead wood, now simply acting as supports. During the

FIG. 1.

FIG. 2.

spring of 1839, I had one of the pillars laid bare (Fig. 1, A), thus confining the life-supporting action to the remaining three. In a short time afterwards, granulated masses of cellular tissue began to form on the upper lip of the incision made, and continued to extend down the surface of the bare pillar throughout the summer, whilst the lower lip of the incision remained free from wood-formation. The woody matter continued to increase rapidly through the summer of 1840, extending itself both in perpendicular and lateral directions from the upper lip. On the lower lip two leaf-buds were formed (Fig. 2, C), which produced young shoots, when woody matter began to form at the bases of these shoots; but on their being removed, the farther increase of tissue at once stopped. In May, 1841, the masses of cellular tissue and wood had extended from the upper lip so as to touch the lower, and to spread along its surface.

“ When the junction took place, a second of the pillars

was laid bare, as the first had been, and the results were similar. The only difference observable was, that the woody matter did not form so rapidly as it did in the first instance. At the expiration of three more years, a second junction had taken place on the pillar last laid bare. A third was now subjected to the same experiment, the principal difference of results in this case being, that no leaf-bud was formed on the lower lip. As soon as the third junction occurred, the fourth pillar was treated as the others had been, the growths of young wood becoming gradually weaker on each succeeding one being the only difference.

“ Having now detailed the way this experiment was conducted, the facts elicited enable me to deduce :

“ 1st. That every organ in an exogenous tree may be thoroughly destroyed, without causing the death of the plant, provided they are gradually destroyed.

“ 2nd. Exogenous plants, through their vital processes, have the power of again restoring the organs so destroyed.

“ 3rd. The formative energy takes place principally above the wounded portion of the stem, and the newly formed tissues increase, for the most part, in a downward direction.

“ Though these results may, at first sight, appear to be little more than confirmations of the old theory of wood-formation, and even the experiment itself in some degree similar to others which have already been made, the latter differs materially from any I know of, in the following particulars. Here the main stem of the tree was operated on, and not the branches only. All the organs were destroyed, including pith, medullary rays, and wood. In the course of twelve years the stem of a large exogenous tree, measuring four feet nine inches in circumference, has been completely killed in a circular ring seven inches wide, and the organs of vitality again restored, without apparently affecting the health of the tree, which is now, while I write (June, 1851), in full bloom. The results, I conceive, rather than adding confirmation to the es-

tablished theory, bear out Dr. Schleiden's views in a remarkable manner. It is true the newly-formed tissue extended from the upper lip of the cut chiefly in the downward direction, and that very little appeared on the lower lip. But the train of reasoning I adopt from these circumstances is that of Dr. Schleiden. The flow of sap by endosmotic process from cell to cell, was interrupted by the alburnum and cambium being cut across on the pillar which was laid bare. It therefore diverged laterally, and followed its natural upward course, on the three pillars where no laceration had been made, which accounts for no growth taking place on the lower lip. On the portion of stem above the cut, a greater degree of formative energy accrued, in consequence of the interruption the endosmotic process met with below. The tissue thus formed would rather extend itself on the vacant space under, i. e., the bare pillar, than upwards, where endosmosis was less vigorous, in consequence of many of the cells being filled with sap of greater density. In this manner it continued to grow until it reached the lower lip of the cut, where its downward course was obstructed, when it spread in a lateral direction over the surface of the lip, as well as upwards, until the bare surface became covered over. During the whole process it did not occur to me, that the young wood was formed by a returning bark-sap. The growth seemed gradual and not periodical. The young tissue taking a lateral and upward direction when it met the lower lip, shows that, although the tendency be downwards, it will alter.

“A remarkable example of the permeability of the tissues of plants has farther been proved through this experiment. From knowing the heart-wood was dead at the part of the stem which was operated on, I was desirous to ascertain whether it continued so to the apex of the tree, which I had some reason to suppose it did, from having about four years ago observed a small portion of the top shoot dead. I, however, found the heart-wood full of sap, and apparently very healthy, in a piece

of the top shoot which I had lately cut from below the dead part.

“With similar objects in view, a second series of experiments have been made, at various times within the last twelve years, by planting cuttings of free-growing plants with their tops downwards. Placed in this way, adventitious roots were protruded, and the plants grew. Cellular granulations at first appeared on the end which was now uppermost, and out of the ground, a circumstance which militates against the inference drawn by some, namely, that the physical law of gravitation operates in causing the sap to descend.

“In conducting this experiment I have invariably found, that no cellular callus formed at the lower extremity, as would have been the case had I planted the cutting in the regular way. The young roots were protruded laterally from the bases of leaf-buds under ground; when one or more of these elongated, the axis made a sharp curve upwards, until it regained its natural position. The growth and woody formation went on then in the usual way. In some cases the portion of the cutting above ground remained alive during a considerable period, though no leaf-buds grew on it. It, however, soon died after the ascending shoot gained strength.

“This experiment, in my opinion, also tends to prove, that no regular return of assimilated bark-sap takes place in the formation of wood; because, if such were the fact, the position of the cutting above ground would have lived, and continued to receive the annual deposits, which was not the case.

“The beautiful example I have laid before the Academy, of the junction of stock and graft, proves, beyond any manner of doubt, that the two increase by separate growths of their own wood, as thoroughly as if they still grew on separate roots. I cannot, therefore, see how this fact can be got over by those who hold that exogenous plants increase by annual deposits of bark-sap. It will not, however, do to draw final

conclusions from isolated cases on a subject which, if Dr. Schleiden's reasoning be correct, so great a change must necessarily follow in our views of this part of the science of vegetable physiology.

“ The present communication may, perhaps, have a tendency to direct more marked attention to the matter, by some of the Members of the Royal Irish Academy.”